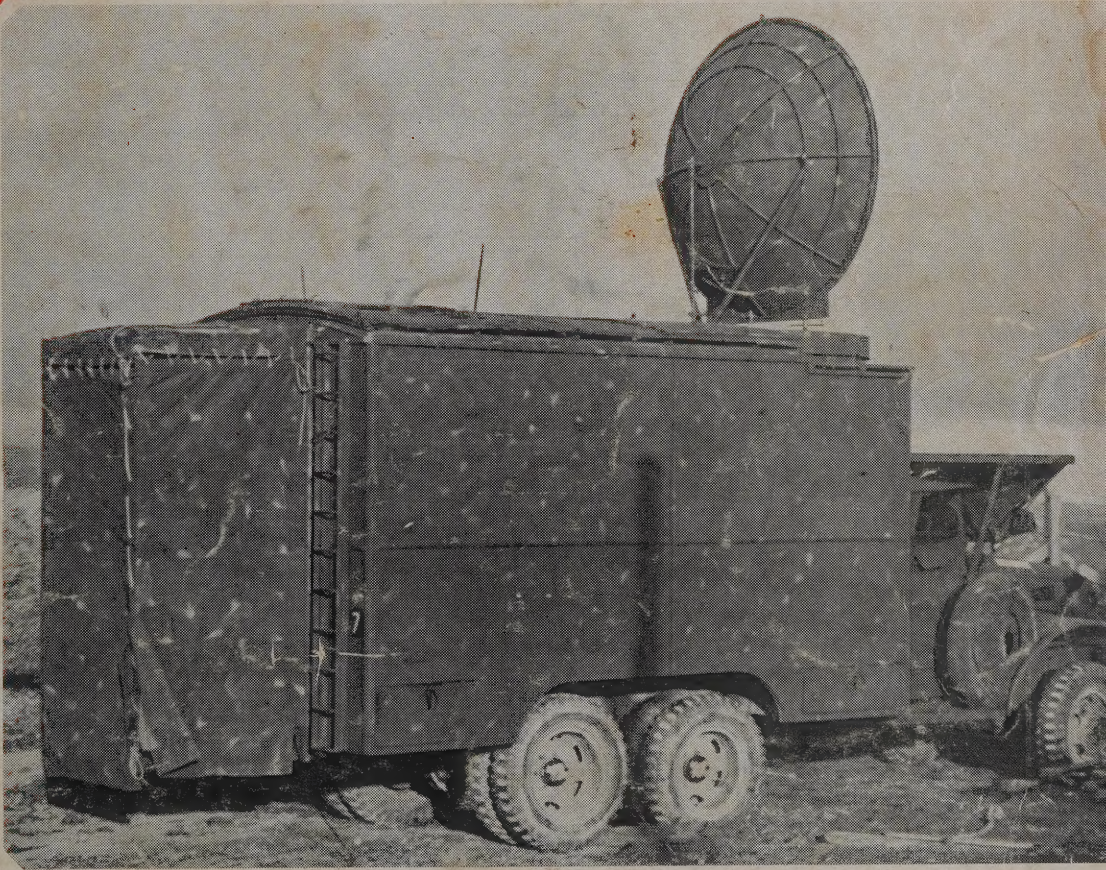
RADIO and ELECTRONICS



INCLUDED IN THIS ISSUE:

JUNE, 1946.

RADAR.
THE CANTERBURY PROJECT.
DESIGN SHEET No. 1.
AN IMPROVED VOLUME EXPANDER.
MORE ABOUT THE RADEL ONE.
MATCHING TRANSFORMER RATIOS.

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RADIO and ELECTRONICS

Vol. 1 No. 3 June, 1946

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OUR COVER

This month's picture is a view of a New Zealand-built mobile radar set. In this month's Radar article is an illustration of the interior of a similar mobile radar, also built by the Radar Development Laboratory.

CORRESPONDENCE

All correspondence, contributions, and enquiries referring to advertising space and rates should be addressed to:—

The Editor,
"Radio and Electronics,"
Box 22,
Government Buildings P.O.
WELLINGTON.

BUSINESS ADDRESS:
46 Mercer Street, Wellington.

TELEPHONE:
Wellington 44-919.

NEXT MONTH. Included in next month's issue are:

For the Amateur: A High Performance 10-Metre Converter.

For the Home-constructor: A 5-Valve Broadcast Receiver.

For All: "Atomic Energy."

SHORTLY IN OUR PAGES we will be publishing:
A Simplified 3-inch Oscilloscope. A Volt-Ohm-Milliammeter. A Six-Valve Dual-Wave Receiver.

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The Amateur Experimenter

In these days of high scientific achievement is there anything the amateur can do that is likely to be of lasting value to radio?

There have always been amateur experimenters in many branches of pure and applied science, and no doubt there always will be. In days gone by, when the universities and learned societies knew no more about some phenomena than did the man in the street, scientific discovery was open to anyone with the inclination, time, and disposition to study such phenomena in a logical and scientific manner. In fact, many important discoveries were made by men who to-day would certainly be classed as amateurs.

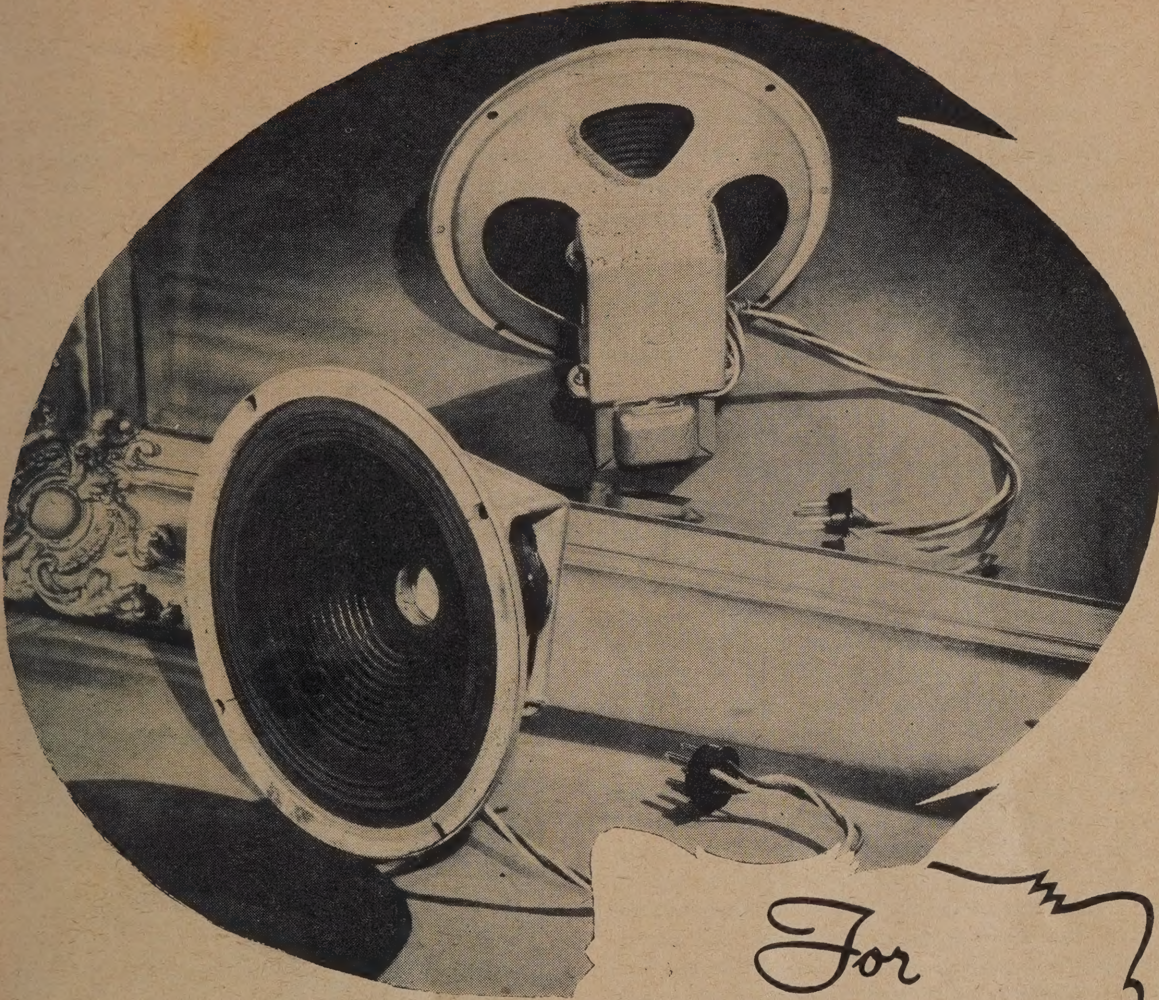
Now, however, the situation is different. The sum of human knowledge is so vast that no single brain can compass it. Not only must scientists or engineers specialise in a particular subject, but in a branch or even sub-branch of that subject, in order that new fields may be explored. On the face of things ,the day has gone when the amateur, with limited resources in equipment and scientific training, can pursue a line of experiment and produce results that will even interest the expert scientist or engineer.

The face of things, however, is no more a reliable guide to truth than ever it has been; human knowledge may be vast, but what remains to know is always vaster. Dr. F. E. S. Alexander, a physicist of considerable repute who has done some fine work in the sphere of radar in New Zealand, and who wrote the article in the first issue on "The Sun's Radio Energy," has pointed out that the first observation of high-amplitude noise from the sun was made by a British amateur transmitter, who reported the phenomenon to Sir Edward Appleton, the noted authority on radio propagation. Similarly, it was an R.N.Z.A.F. radar officer who, without previous knowledge of the effect, reported its occurrence on a frequency of 200 Mc/sec.

The day of the amateur observer is not past, then. Nor would Dr. Alexander's final paragraph refute this, for she says, "In observations of this type, amateurs can play a most important part. Anyone who cares to build an ultra-short wave receiver can be fairly sure of collecting useful information."

There are doubtless many experimenters who would like nothing better than to feel that, by their own efforts, they were advancing in some measure our knowledge of radio. For them, Dr. Alexander's words will be a real incentive to apply the knowledge they have gain in creating more.

To this end, therefore, "Radio and Electronics" is prepared, should interest prove great enough, to publish the design of an ultra-short wave receiver and aerial system suitable for the work suggested by Dr. Alexander. We will further assist all who may undertake the work by receiving their detailed results, and transmitting them to the Department of Scientific and Industrial Research, or to any other authority who can make the greatest use of the information collected. In this way we too can play our small part in the advancement of radio and through it, its parent science, Physics.



RADAR

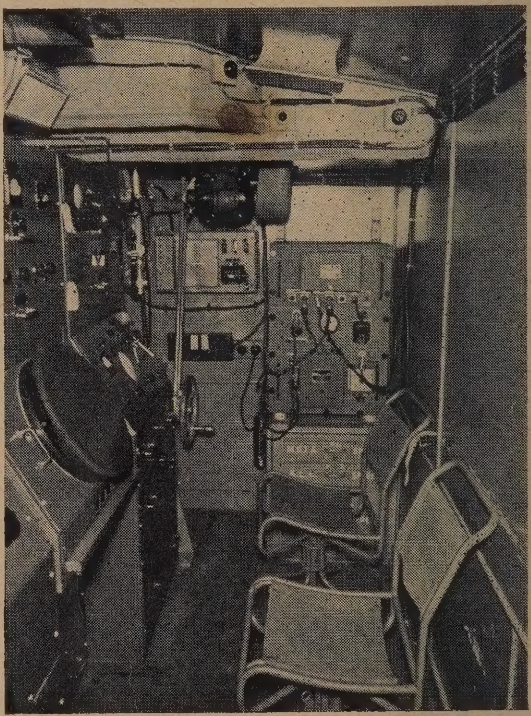
Illustrated in this article is a mobile radar unit of which New Zealand may feel justly proud. With the exception of certain components such as tubes and meters, it was designed by the Radio Development Laboratory—a branch of the Department of Scientific and Industrial Research—and manufactured entirely in this country.

Tactical operations are based on a knowledge of the enemy's disposition and movements, and in providing continuous and accurate information radar proved to be of vast importance.

Fixed radars are of indisputable value in a defensive situation, as was proved in the Battle of Britain, but when the allied offensive was being planned, the need for mobile radar was obvious. When the American Task Forces landed on isolated, heavily defended Japanese occupied islands in the Pacific, the sterling work carried out by mobile radars amply justified the colossal effort involved in their production, transportation, and operation under exceedingly difficult conditions. A task force, clearing a perimeter round its beach-head, must have adequate warning of the approach of enemy aircraft.

Equipment similar to that illustrated here was used in the landing on Green Island, and under the direction of Honorary Captain Clive Liddell and his team from the Radio Development Laboratory the set was landed, its aerials were erected, and it was plotting enemy aircraft only a few hours after the initial landing, and while the U.S. troops were still strenuously fighting to widen the perimeter.

Perhaps the most interesting aspect of this type of equipment is the presentation of the radar information. In the first of our articles dealing with radar, we discussed the fundamental principles and described the simplest type of presentation—the cathode ray tube screen on which the reception of an echo was displayed as a vertical deflection on a horizontal time-base. This method is known in radar circles as "A-scope presentation." As more uses were found for radar the question arose of presenting more information than range only, on a single cathode ray tube. Thus more complex types of display were developed, among them being the P.P.I. or Plan Position Indicator. As its name suggests, this indicator presents echoes in range and bearing simultaneously, so that the final result is very like a map of the area surrounding the radar set, echoes appearing on it in their correct positions relative to the centre, which represents the location of the radar. This enables a large area to be viewed at a glance, and renders possible the tracking of several targets simultaneously. The P.P.I., however, is usually supplemented by an "A-scope" so that the nature of the echo may be studied, and accurate ranging and identification more easily accomplished.



HOW THE P.P.I. WORKS.

The basis of the P.P.I. is a cathode ray tube with an unusually long-persistence screen. The latter feature is secured by means of two fluorescent coatings on the screen instead of the usual single coating. One of the coatings—the one nearest the electrode structure—is excited in the normal way by the electron beam, and has a blue

fluorescence of short persistence. The highly actinic blue light from the inner coating in turn excites the second coating, which has a brownish yellow glow, lasting for periods as great as one minute after the electron beam has passed. Thus, for reasons which will be explained, the echoes may be seen for the period of this long afterglow, "painted" as it were, by the blue light from the normal short-persistence coating.

The time-base, unlike that of the "A-scope," starts from the centre of the P.P.I. tube, and extends to the edge of the tube, like a single spoke of a wheel. Range, therefore, is measured by noting the distance of an echo from the centre of the tube. Thus far, except for the long-persistence screen, the P.P.I. works similarly to the A-scope.

To see how *direction* is brought into the picture, we must consider how this is measured, fundamentally. The aerial of the radar set is very highly directional, sending out a narrow beam of energy. Thus, when the aerial is pointing directly at a target, the echo can be seen to be at maximum amplitude. Finding the direction of a target from the radar simply consists in finding in what direction the aerial is pointing when the echo is received at greatest strength.

So far, our picture of a P.P.I. consists only of a cathode ray tube with a time base extending from the centre to the edge of the tube. All that has to be done to indicate the direction of a target is to so arrange matters that the spoke-like time-base rotates in synchronism with the aerial. Now suppose the top of the P.P.I. is labelled "North." The gear which rotates both aerial and time-base is set up so that when the former points to the north, the latter points in the direction marked "North" on the tube perimeter. Now, as long as aerial and time-base rotate in synchronism, the direction of the time-base will always represent the bearing on which the aerial is pointed.

To complete the picture, it should be pointed out that on the P.P.I. echoes are displayed not by a deflection at right angles to the time-base, as in the A-scope, but by a brightening of the trace. This is easily accomplished by feeding the signals from the receiver to the grid of the cathode ray tube instead of to a deflecting plate. The brilliance control of the tube is usually adjusted so that the time-base is just invisible. Then the extra brightness caused by a returning echo makes a bright spot to appear. The aerial (and time-base) rotate continuously at a speed of about six revolutions a minute, so that every ten seconds the whole area round the radar is scanned, and echoes show up as bright spots on the tube-face, their range and bearing from the radar being accurately presented. The purpose of the long afterglow is to enable the echoes to remain visible after the time-base has moved further round the tube, and until it has made a complete revolution, when a new echo is produced. This virtually means that the time-base paints a map-like facsimile of any objects within range, whether aircraft, ships, or land masses. The illustration on the front cover of our May issue was a photograph of a P.P.I. taken while ship-borne tests of a radar set were in progress.

TIME-BASE SYNCHRONISATION.

There are several schemes that have been used to synchronise the rotation of the P.P.I. time-base with that of the aerial, but all of them depend on the use of the Selsyn. This is a small machine, often no bigger than a man's hand, and can be used either as a generator or a motor. In its simplest form it consists of a single-phase rotor and a two-phase stator. This type is used in some British equipment, and provides the simplest form of rotating time-base.

One selsyn is used as a generator, and has its rotor coupled through a gear-train to the main shaft of the rotating aerial. The second selsyn is used as a motor, and drives, through similar gearing, a rotatable deflection coil round the neck of the P.P.I. tube. Both rotors are supplied with 230v. a.c. from the mains, and corresponding stator windings of the selsyns are connected together. When the generator rotor is at rest (*i.e.,* when the aerial is not rotating) its field is in a particular direction with respect to the stator windings.

Thus, the voltages induced in the latter depend in magnitude on the position of the rotor. These voltages are led to corresponding stator windings of the motor, so that the resultant field inside the latter lies in a direction corresponding to that of the field in the generator. In this way, the direction of the field in the motor depends at all times on the position of the generator rotor. Now if the motor's rotor winding is in any position other than at right-angles to the field in the motor, it will be subject to a force which will turn it until this condition obtains. Thus, the position of the motor shaft is determined by the position of the generator shaft. If the latter rotates, as when the aerial turns, the field in the generator rotates, the field in the motor rotates, and the motor shaft rotates

in synchronism with the aerial, and if the latter stops, the deflection coil stops, too, in a corresponding position.

In the Radio Development Laboratory radar illustrated, the system used for rotating the time-base is rather different, though still depending on a selsyn generator for its action. Here, the time-base saw-tooth wave form is fed to the rotor of the generator, this being mounted on the aerial shaft as usual. Round the neck of the P.P.I. tube is a fixed deflection yoke whose windings correspond exactly to those of the generator stator. The field inside the deflection yoke therefore corresponds in direction to the position of the generator rotor, exactly as before, the only difference being that in this case, the motor's rotor is the electron beam itself! Since the wave-form of the field is a saw-tooth, the result is a linear time-base, rotating in synchronism with the generator shaft, and therefore with the aerial.

The advantage of this system over the one previously described is that one mechanical linkage is eliminated, with its attendant back-lash. The circuitry, however, is much more complicated, since there must be an amplifier between each stator winding of the generator and its corresponding deflection yoke winding. In addition, considerable difficulty is experienced in passing the saw-tooth through the system without distorting it. In fact, it is necessary to introduce distortion into the saw-tooth *before* it is fed to the selsyn generator, so that the correct wave-form may be produced by the deflection yoke. However, the two systems work equally well when properly adjusted, and both are a fine tribute to the ingenuity and resource of our war-time scientific workers.

QUESTIONS AND ANSWERS.

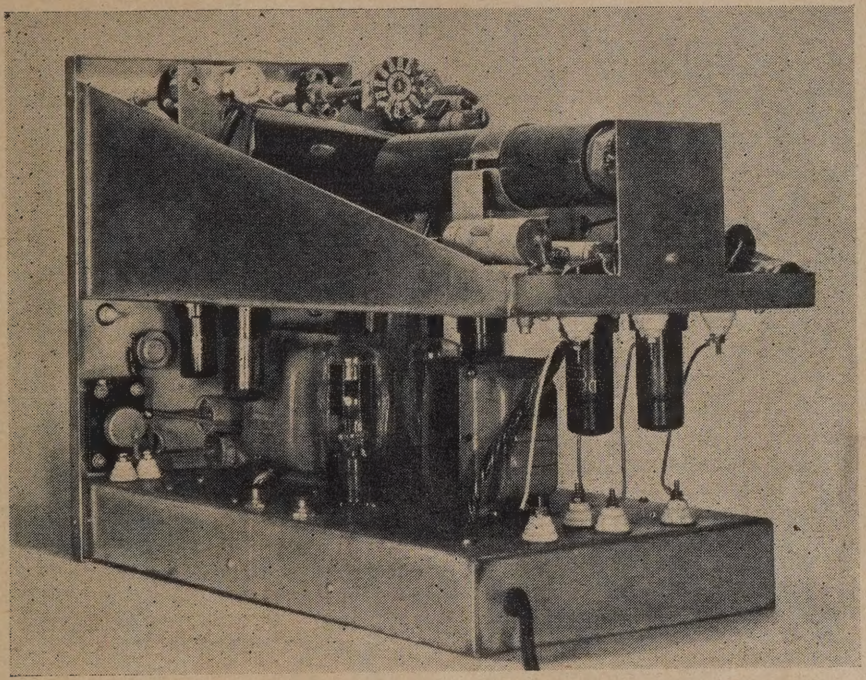
As a further service and interest to our readers we intend to devote a section of *Radio and Electronics* to answering any technical problems that may arise. We therefore ask all who have technical queries to submit them, together with a stamped, addressed envelope for reply.

All questions will be answered, either by letter or in *Radio and Electronics,* but it is anticipated that not all will be published, owing to restrictions of space.

We would ask all who submit queries to give us as complete data as possible, for many questions cannot be properly answered unless all relevant information is given.

—The Editors.

A 5" SERVICE OSCILLOSCOPE



PART 2.—POWER SUPPLY AND TIME BASE CIRCUITS.

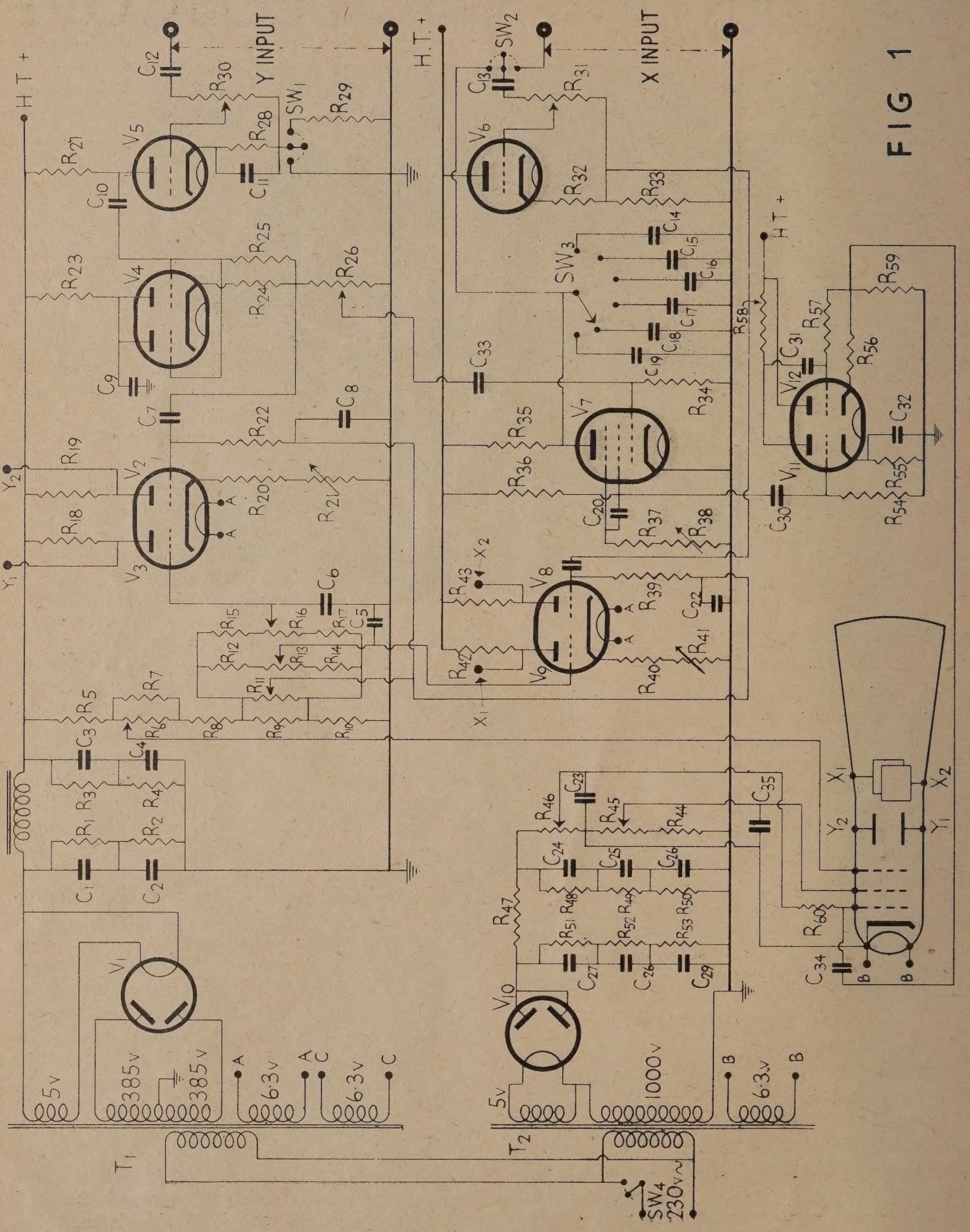
Part 1 of this article dealt in a general way with the features peculiar to this oscilloscope, and commenced a detailed description of the circuit by describing the operation of the cathode-coupled push-pull deflection amplifiers. It was shown how this special circuit provides balanced deflection voltage from a single-ended input, balanced, instantaneously acting shift control, and astigmatism control.

For convenience, the full circuit diagram and component list are reproduced here, so that anyone who missed the May issue of "Radio and Electronics" will still have at hand all the essential data.

POWER SUPPLIES.

Since the design of the power supply circuits is influenced by the use of cathode-coupled amplifiers, it seems logical that these should be described next. The low voltage power supply is quite conventional, and delivers H.T. voltage to all stages of the amplifier and time-base circuits. The power transformer is a 385 v. a side 80 ma. receiver type power transformer, with the addition of an extra 6.3 v. heater winding. An 80 is used in the normal manner as a full wave rectifier and works into a condenser-input filter. The current drawn by all stages is quite light; in fact nowhere approaching the 80 ma. rating of the transformer, but the latter has been used with the idea of providing as high an H.T. voltage as possible from the 385 v. winding. The secondary resistance of an 80 ma. transformer is usually less than that of a smaller one, so that the regulation at light current loading is better, and a slightly higher H.T. voltage will be available.

The filter condensers are made up of two 16 $\mu f.$ 450 v. electrolytics in series. This is to make quite certain that breakdown, particularly of the input condenser, will not occur. This precaution is necessary with the light load imposed on the secondary. R_1-R_4 are shunted across the individual condensers as a protective measure. All electrolytic condensers have some leakage, and if the leakage of one of a pair in series is much less than that of the other, the voltage will not be distributed equally across the two condensers. The greatest voltage will build up across the good one, with the result that it breaks down. The



Y INPUT
X INPUT
H.T.+
H T +
SW1
SW2
SW3
SW4
230v~
Y1
Y2
X1
X2
5v
385v
385v
6·3v
6·3v
1000v
T1
T2

FIG 1

COMPONENT LIST.

C_1-C_4 = 16 μf. Electrolytic.
C_5, C_6, C_{14}, C_{20}, C_{23}, C_{24}-C_{29} = 1 μf. 600 v paper.
C_9 = 8 μf. Electrolytic.
C_{11}, C_{32} = 50 μf. 50 v. Electrolytic.
C_{15} = 0.25 μf. 600 v.
C_{16} = 0.05 μf. 600 v.
C_{17}, C_{33} = 0.01 μf. 600 v.
C_{13}, C_{30}, C_{31} = 0.1 μf. 600 v.
C_{18} = 0.002 μf mica.
C_{19} = 0.0005 μf. mica.
C_{34} = 0.25 μf. 1200 v. (see text)
R_1-R_4, R_{22}, R_{25}, R_{39}, R_{44}, R_{54}, R_{57}, R_{60} = 1 Meg.
R_5, R_8 = 10 k.
R_9, R_{10}, R_{12}, R_{15} = 25 k.
R_{14}, R_{17}, R_{34}, R_{37}, R_{55}, R_{58}, R_{59} = 50 k.
R_{18}-R_{20}, R_{27}, R_{29}, R_{33}, R_{36}, R_{40}, R_{42}, R_{43}, R_{47} = 100 k.
R_{23} = 75 k.
R_{24}, R_{28}, R_{32} = 5 k.
R_{35} = 150 k, 2 w.
R_{48}-R_{53} = 5 Meg.
R_{56} = 60Cω.
V_1, V_{10} = 80.
V_2 + V_3 V_4, V_8 + V_9 = 6N7.
V_5, V_6 = 6J5.
V_7 = 6AC7/1852.
V_{11} + V_{12} = 6SN7.

POTENTIOMETERS.

R_6, R_{11} = 0.5 Meg.
R_{13}, R_{16} = 50 k.
R_{21}, R_{26}, R_{41} = 25 k.
R_{30}, R_{31}, R_{38} = 2 Meg.
R_{45} = 1 Meg.
R_{46} = 1 Meg. Pot. with 100 k fixed, in parallel.

T_1 = Power Transformer, 385 v. a side.
T_2 = High Voltage Transformer.
Sw_1 = Y gain switch.
Sw_2 = X input switch.
Sw_3 = coarse freq. selector.
Sw_4 = on/off switch.

1 Meg. resistors used here effectively prevent this trouble from occurring.

A high-resistance bleeder is connected across the power supply at the output of the filter, consisting of R_5 to R_{11} inclusive. This serves two purposes. It provides two adjustable voltages by means of R_6 and R_{11}, which are used only in the initial setting up of the oscilloscope, and are therefore not brought out to the front panel. The bleeder resistances are so proportioned that the variable arm of R_6 can be adjusted to the same potential as the anodes of V_2, V_3, V_8 and V_9. The final anode of the C.R.T. is connected directly to the moving arm of R_6, so that when the latter is properly adjusted, the final anode is at the same D.C. potential as the anodes of the cathode coupled amplifier valves, and therefore at the same potential as the deflecting plates.

In more usual C.R.T. circuits the final anode is connected to earth, but this would not meet the case here, where the deflecting plates are at a high positive potential above ground. The spot would be badly defocussed, as was mentioned in Part 1 of this article.

The potentimeter R_{11} is arranged so that its moving arm may be adjusted to +200 volts. The grid return circuits of V_2 and V_8 are brought to this point, as described in Part 1, in connection with the cathode coupled amplifier. The smoothing choke used in the low voltage power supply is a standard vibrator-type choke, rated at 40 ma.

HIGH VOLTAGE SUPPLY.

The high voltage transformer used in the prototype model has a secondary voltage of 1000, at a rated current of 5 ma. This, in conjunction with an 80 connected as a half-wave rectifier, produces approximately 1100 v. at the output of the smoothing filter. In case this should appear rather low for the H.T. of a 5GPI/5BP1, it should be pointed out that the final anode is at +300 volts, approximately, while the C.R.T. cathode is at —1100 v., so that the total tube voltage is 1400 v. If desired, the high voltage secondary of T_2 could be raised to 1500 v., which would make the total tube voltage approximately 1800 v., but if this is done, higher rated smoothing condensers would have to be used, and in addition the deflection sensitivity of the tube would be reduced somewhat.

When the prototype was built, high voltage oil-filled condensers were not available for the smoothing circuit so that a substitute had to be found. The arrangement is to use three 1 μf.

600 v. paper condensers in series for each smoothing condenser. This gives quite adequate smoothing, and a rated voltage of 1800 v. for each condenser. As with electrolytics in series, it is preferable to use, as we have done, balancing resistors across the series condensers. Since the leakage of paper condensers should be negligible these resistors, R_{48}—R_{51} on the circuit diagram, may be made 5 megohms each with quite satisfactory results. If oil-filled or oil impregnated condensers are available, the series units may be replaced by 0.5*uf* 2000 v. single condensers. There would enable the higher voltage supply to be used, if desired. The smoothing resistor R_{47} is a 100,000*w* 1 watt, and is a suitable compromise between smoothing effect and voltage drop.

The total resistance of the high-voltage bleeder consisting of R_{44}, R_{45}, and R_{46} is 2.1 megohms, so that the bleed current is of the order of 0.5 ma. This is great enough to prevent the appearance of too much interaction between brilliance and focus controls, which occurs if the bleed current is not high enough compared with the beam current of the tube. It will be noted that the cathode of the tube goes direct to the junction of R_{45} and R_{46}, while the grid is taken to the moving arm of the latter. Since the supply is of negative polarity, the grid is therefore negative with respect to the cathode by an amount determined by the position of the moving arm of R_{46}.

THE C.R.T. CIRCUIT.

This follows normal cathode ray tube practice, except in one or two points. The grid connection, described above, is that usually found in oscilloscopes, except for the addition of C_{34} and R_{60}. The latter is placed in series with the lead to the brilliance control potentiometer so that a signal may be fed in to the grid from V_{12} in order to black out the return sweep of the time-base. The focussing electrode or first anode, as it is sometimes called, is taken to the moving arm of R_{45}, which is the focus control. It should be noted that both the grid and first anode leads are bypassed to the cathode tap on the voltage divider. Although the bypass condensers C_{23} and C_{35} respectively are at a high negative potential with respect to earth, the voltages across them do not exceed 500 volts in the circuit used, so that ordinary 1μf. 600v. paper condensers may be used. The connections to the deflecting plates have already been described in connection with the cathode coupled amplifier.

THE TIME-BASE.

Oscilloscopes of the type we are concerned with usually employ a gas-triode type of time-base. This is comparatively simple in design, and can be made sufficiently linear for all ordinary purposes without much difficulty. Its main limitation is that above about 20,000 cycles/sec the amplitude of the saw-tooth produced drops off quite rapidly, and at the same time the linearity becomes rather poor. For instruments designed to cover only the audio range this does not matter very much, so that the gas-triode finds much use as a time-base valve.

Here we have used a hard-valve type of time-base, with a 6AC7/1852 in a "Transitron" circuit. Although the choice of a hard-valve time-base was governed mainly by the non-availability of 884 or 885 types, the transition circuit was picked as being the best compromise between practicability and performance. Intending builders need have no fear that the circuit given will not perform at least as well as a gas-triode circuit. In some particulars, in fact, the transitron circuit has very great advantages over the former.

ADVANTAGES OF THE TRANSITRON.

In the first place, the transitron gives much better high-frequency performance than the gas-triode. Not only will it keep on working up to 200kc/sec, and even higher, but its wave form at these high frequencies is excellent. At comparatively low frequencies, where the gas triode is beginning to struggle, for instance round about 25kc/sec, the performance is as good as the gas-triode performance at low frequencies.

Secondly, synchronisation of the transitron is very easy and very positive in action—a statement that cannot always be made for other time-base circuits. For example with the prototype, it was just as easy to examine the wave form of a broadcast-band oscillator as that of an audio oscillator on 1000 c/sec. The oscillator could be tuned over its whole range after the synch-control had been set, and the picture would lock on every additional cycle without any readjustment of the oscilloscope controls!

A third advantage is that the transitron provides ready-made, a pulse that can be used to render the fly-back invisible. This is really just as well, for one of the poorer features of the circuit is that the fly-back is not very fast, and

can very easily be seen. If blacked out, however, it can cause no confusion of the picture.

HOW IT WORKS.

Although a detailed discussion of the operation of the transitron time-base is outside the scope of this article, a brief description will be given which should be useful to anyone who has not met the circuit before. On the circuit diagram V_7 is the time-base valve and is a 6AC7/1852. The grid is unbiassed, so that grid-return and cathode are both taken directly to earth. R_{35} is a plate resistor connected to H.T.+, while any one of the condensers is connected from plate to earth by means of the selector switch sw_3. The screen is fed from H.T.+ through R_{36} in the normal manner, but is not bypassed to earth. Instead, it is coupled to the suppressor by means of the $1\mu f.$ condenser C_{20}. The suppressor is returned to earth through R_{37} and R_{38} in series. When a pentode is connected in this way, a peculiar penonmenon arises in that the tube will act as an amplifier *from suppressor to screen.* Thus, if the screen voltage falls, this change is transmitted to the suppressor by C_{20}. The fall in suppressor voltage causes the screen voltage to fall lower still, and so on. The nett result is a very sudden fall in screen and suppressor voltage, sufficient to cut off the plate current. While the plate current is cut off, the condenser in the plate circuit charges up through R_{35}. This charging of the plate condenser constitutes the linear rise of the saw-tooth. Now the very rapid fall in suppressor voltage that caused the plate current to be cut off also partially charged up condenser C_{20}. After a time (during which the plate condenser is charging) the charge on C_{20} leaks away through R_{37} and R_{38}. A stage is therefore reached where plate current starts to flow once more. This causes the screen current to fall, and therefore the screen voltage to start rising. With it ,the suppressor voltage rises too, and a triggering action is again called into play; but this time, the result is a very sudden onset of heavy plate current. The latter causes the plate condenser to be equally suddenly discharged. Thus the wave-form at the plate consists of a linear rise followed by a sudden drop—the well-known saw-tooth time-base wave-form. The polarity of the saw-tooth is positive-going. The rapid rise of screen voltage occurs at the end of the time-base sweep, or (which is the same thing) the begin-

This page is contributed monthly by the New Zealand DX Radio Association (Inc.), 20 Marion Street, C.2, Wellington, New Zealand. All "DX" and Club enquiries should be addressed direct to the Association.

THIS "DX-ING"

ANNUAL GENERAL MEETING.

The New Zealand DX Radio Association Inc. held the Ninth Annual General Meeting in the Trades Hall, Vivian Street, Wellington, on April 20, 1946.

Our President, Mr. A. Kindell, presided over delegates and members of branches throughout New Zealand. Many matters affecting the Club and "Tune In" were discussed and the Constitution brought up to date. We hope to see the Club grow and new branches start. Altogether a very enthusiastic gathering.

SHORT-WAVE NOTES

The following is a line up of Short-wave Notes for the month. Among them are some from our Australian members:—

JODK, 2.510, Seoul, Korea, 9 p.m.-1.30 a.m.—Has dance music at midnight.

AFRN, 6.070, Frankfurt, Germany.—Best heard 5.30-6.30 p.m., American records, weather reports and general information for troops in occupation zone. Frequent time announcements (1 hour ahead of GMT).

Luxembourg, 6090 Kcs.—New frequency heard with dance programme in English at 2115 G.M.T.

CBRX, 6.160, Vancouver, B.C., Canada.—Relays CBR. News at 6 p.m. usually followed by talk. Signs at 8 p.m., last hour usually dance music. Fair sig.

JVT, 6.750, Tokyo, Japan.—Contacts WVLC after midnight. Plays recordings and excerpts of AFRS programmes. Good sig.

Athens, 7295 Kcs.—Heard testing with music until closing at 2130 G.M.T.

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Radio Tirana, 7850 Kcs.—Heard closing 2015 G.M.T. with Anthem; both male and female announcers use Italian language.

Radio Balikpapan, 9125 Kcs. 125 Watts.—Heard with musical programme before taking relay from P.C.J. Holland at 1300 G.M.T.; sigs. fair to good.

V.J.Z. Rabaul, New Britain, 9310 Kcs.—Heard strongly calling La Perouse, Sydney, at 1130 G.M.T.

Radio Safia, 9330 Kcs.—Heard with 10-minute talk In English from 2030 G.M.T.

TAP 9.465 Ankara, Turkey.—Very good signal with English news at 5.45 a.m., followed by French news at 6 a.m. Station announcer is woman, and wavelength, frequency and call are given at 6 a.m.; otherwise announces, "This is Ankara" and "Ici Ankara."

O.I.X.2, 9500 Kcs., Lahti, Finland.—Heard at 6.30 p.m.

V.E.9.A.I., Edmonton, 9540 Kcs.—News at 1400 G.M.T.; ipmorev sat 1430.

KRHO, 9.550, Honolulu, Hawaii.—Replaces 6.120 frequency evenings. Very good sig. Several changes taking place in Frisco frequencies.

Hong Kong, 9570 Kcs.—Poor under KWIX; has B.B.C. news at 1300 G.M.T.

Radio Francaise, 9.610, Paris, France.—In North American service has English news, followed by talk at 2.15 p.m. and 3.30 p.m. (also on 11.845). Fair at 2.15 p.m., good at 3.30 p.m. Station announcer usually woman.

CBFX, 9.610, Montreal, Canada.—Announces "Radio Canada," closes at 5.5 p.m. Programmes alternate in Franch and English, but last half-hour usually features dance orchestra and in English programme. Good sig. last 1½-2 hours. Signs with announcements in Franch and English, Canadian National Anthem, and God Save the King.

XEBT 9.625, Mexico City, Mexico.—Relays XEB. GWO interferes badly until 3.30 p.m. then to 5 p.m. fine sig.; after that GWO interferes again; invariably has English announcements after start of programme, commencing at 4.45 p.m.—otherwise all Spanish.

CE970 9.728, Valparaiso, Chile.—Has been heard lately closing at 4.24 p.m. with English announcements. Woman announcer. Fair strength.

HCJB 9.958, Quito, Ecuador.—Signs at 3.30 p.m. In English 2-3.30 p.m. (in parallel with 12.455); fair to good strength. Mostly religious broadcasts. English sessions earlier.

CKRX 11.720, Winnipeg, Canada.—Signs 6.15 p.m. but on later Sundays, when there is usually sports relap until 6 p.m., then request session. Poor to fair strength.

CHOL 11.720, Sackville, Canada.—Good sigs. in European service until late a.m.

K11 13.720, Bolinas, California (with KEJ 9.010) tests with (VLZ 5 or 8) Melbourne, Wednesdays, 5-6 p.m. Both good strength.

CKCX 15.190, Sackville, Canada.—In parallel with CHOL; good sig.; English and various languages used.

WLWL 15.230, Cincinnati, U.S.A.—Signs 11 a.m. Fair to good sigs.

PCJ 17:765, Hilversum, Holland.—In parallel with 15.220 1 a.m. to 2.30 a.m. Tuesday and Saturday; to 3 a.m. remainder of the week. English during "Happy Station" programme with Edward Startz; 1.30 a.m. to 2.30 a.m. Monday and Thursday; also uses 9.590 to South Africa, 7-8 a.m. (to 8.30 a.m. Monday and Thursday) and 1-2 p.m. to Dutch East Indies and America. Requests reports. Good sigs.

AN IMPROVED VOLUME EXPANDER

An introduction to the subject of volume expansion, followed by a complete description of a well tried circuit.

It has long been recognised that the volume-range of many gramophone records is not nearly as great as it should be. In other words, the loudest parts of a record are not as loud as they should be in comparison with the softest passages.

In the old days of electrical recording this was one of the least troublesome types of distortion that the engineers had to deal with, not because it was not important, but because frequency distortion and non-linear distortion were relatively much more so. More recently, however, these two faults have to a large extent been overcome, with the result that distortion of the dynamic range has become one of the major issues in the improvement of most types of recording.

DYNAMIC DISTORTION.

The chief difficulty in this respect has been the fact that if records were to be made at all, compression of the volume range was a necessity, and had to be introduced on purpose. Nor is it difficult to see why. All types of disc suffer from a certain amount of surface noise, consisting of both "needle scratch" and turn-table rumble. Now suppose that an orchestral piece is being recorded, and that in it is a single violin playing *pianissimo,* followed by the full orchestra of eighty or so players, *all* playing *fortissimo.* What is the recording engineer to do? If he turns the volume control so that the solo violin can just be heard over the surface-noise, the crash of the full orchestra will overload the groove, with disastrous results. If on the other hand he turns the control down, till the loudest passage does not overload the record, and leaves the control set, the solo will be so lightly recorded that is is lost in the surface noise, and cannot be heard at all. The only way out of this dilemma is to turn the volume control *up* during the soft passage, and *down* during the loud one. In this way both portions are recorded. Each is satisfactory in itself, but the relative volumes are all wrong!

VOLUME EXPANSION THE CURE.

Modern advances in recording technique have helped a great deal to remedy this state of affairs. Present day recordings have a much greater dynamic range than have records made ten years ago, but many people buy and play records even older than this, so that if we can do anything, in playing a record, to restore the volume range to something like its original value, we should achieve a great increase in realism.

Since we require an increase in dynamic range, we want loud passages to be louder still. The ordinary amplifier amplifies all volume levels by the same amount, and so has no effect on the dynamic range, but if an amplifier amplifies loud passages more than it does soft passages, it has increased the dynamic range and achieved our purpose. This kind of amplifier is known for obvious reasons, as a volume expander.

EXPANSION OR NO EXPANSION.

From time to time many arguments have been advanced against the use of volume expansion. Some of them, it must be admitted, are quite powerful and deserve their fair share of consideration. Others, however, are merely based on the premise that a *good* volume expander is difficult to design. By far the majority of "anti-expansionists" say that a good enough expander has not yet been designed, and if it were, would be difficult to use. Admittedly it is not perfect, and it does need to be used with discretion, but we feel sure that the improved circuit described here will prove interesting to experimenters and gramophone enthusiasts, and will certainly repay the time and trouble expended in building it.

THE CIRCUIT.

The figure is the circuit of a complete expander using a 6L7 as the variable-gain amplifier. The action may briefly be described as follows:—

The pickup output goes to the 500K input potentiometer. This acts as an input control to the 6L7, but applies the full input at all times

to the grid of V_2. The latter acts as a normal resistance-coupled amplifier. Its output, however, is rectified by the 6H6 diode. The rectification of the audio frequency voltages is exactly analogous to the action of a diode detector on a carrier.

In the R.F. detector, the diode develops across its load resistor a direct voltage which is proportional to the strength of the carrier. In the present case also, a direct voltage is produced across the load resistor, R_{11}; here, however, its amplitude is proportional to that of the audio input voltage. The direct voltage is filtered to remove audio frequencies, and is applied as a biassing voltage to G_3 of the 6L7.

It would appear then, that the expander is simply an audio amplifier (the 6L7) which has an A.V.C. voltage applied ot a separate grid, rather than to the signal grid. This is, in fact, the case, with one important difference. An examination of the 6H6 circuit will reveal that the polarity of the control voltage is positive instead of negative. Thus, the stronger the audio signal to the rectifier the greater the amplification of the 6L7. This is the required characteristic to give volume expansion.

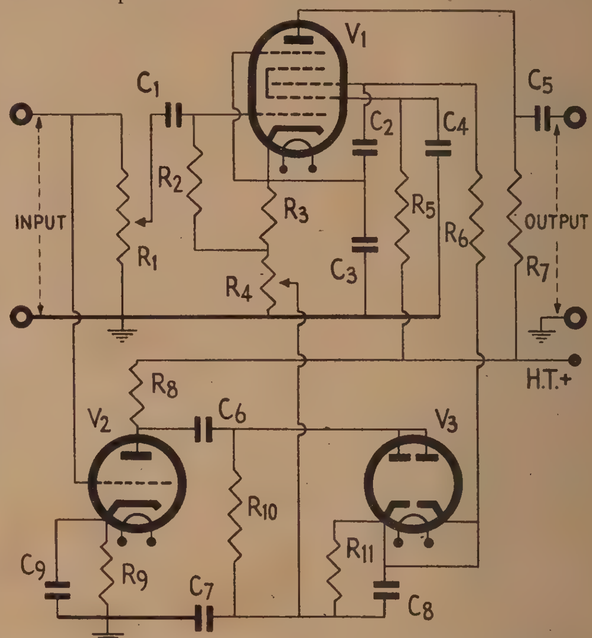
IMPROVED BIAS CIRCUIT.

Most 6L7 expander circuits use a voltage divider to obtain the necessary operating voltages for G_1, G_3 and the screen of the 6L7. These circuits are very difficult to adjust, even with the aid of a meter. In the present circuit, the screen votage is obtained from a resistor R_5, while bias voltage for G_1 and G_3 are obtained from the cathode resistors R_3 and R_4 in series. G_1 is returned through R_2 to the lower end of R_3. The drop across the latter places a bias of —3 volts on G_1 at all times.

G_3, however, is returned through R_6 and R_{11} to the moving arm of R_4. If the latter is at the top, G_3 has the same bias as G_1, namely —3 volts. But if the moving arm of R_4 is at the bottom, the full voltage across R_3 and R_4 is applied to G_3 as bias. The maximum bias for G_3 is about 15 volts negative, so that by means of R_4, its standing bias may be varied from —3 to —15 volts, the bias on G_1 remaining fixed at —3 volts. This arrangement entails no critical adjustments whatever.

HOW EXPANSION ARISES.

The potentiometer acts as a control of the degree of expansion, and its action may be explained as follows: G_3 of the 6L7 has a variable μ characteristic, so that its gain varies in accordance with the D.C. bias on G_3. When the latter is —3 volts, the gain is a maximum, and any decrease caused by the control voltage from V_3 is ineffective in altering the gain of the 6L7. Thus, with R_4 set to the top of its travel, there is no expansion.



Now, suppose R_4 is set so that the standing bias on G_3 is —6 volts. Control voltages of up to 3 volts will now be effective in increasing the gain of the 6L7, so that a certain amount of expansion is obtained. If now R_4 is set so that the bias on G_3 is —9 volts, control voltages of up to 6 volts will now be effective, and more expansion will be obtained than before. Thus, the more negative the steady bias on G_3, the more expansion will be obtained, always provided that enough control voltage is available to swing the latter up to —3 volts.

PREVENTION OF OVERLOADING.

From the above description it can be seen that however much expansion is being used, the gain of the 6L7 can never become greater than when the expansion control is set to the position which gives no expansion. This is a very useful property of the circuit, for it can be used to prevent the main amplifier from being overloaded at high values of expansion.

To do this, the record is played through the expander with the expansion control set at zero. While the record is playing, the volume control

COMPONENT LIST.

V_1 = 6L7.
V_2 = 6C5.
V_3 = 6H6.
R_1 = 0.5 Meg. Pot.
R_2, R_6, R_{11} = 0.5 Meg.
R_3 = 400ω.
R_4 = 2000ω Pot.
R_5 = 50 k.
R_7 = 20 k.
R_8, R_{10} = 100 k.
C_1, C_5 = 0.1 μf.
C_2, C_8 = 0.25 μf.
C_3, C_7 = 25 μf. 25 v. Electro.
C_4, C_9 = 0.5 μf.
C_6 = 0.05 μf.

on the main amplifier is set for a suitable maximum volume on the loudest part of the record. The expansion control is now set to give the desired amount of expansion, and the record is played without altering the setting of the volume control. Careful listening will reveal that the maximum volume is the same as it was without expansion, but that the range from loudest to softest is much greater than before.

THE INPUT POTENTIOMETER.

The input control R_1 is provided so that too much signal is not supplied to the 6L7. If this is done, there will be noticeable distortion owing to the curved characteristic of the 6L7, but if the input is kept smaller than about ½ volt, the distortion will be negligible.

A useful way of ensuring that the input to G_1 is not too great is to set the main amplifier gain control at its normal position and turn down the input control in the expander until the volume is the same as without the expander in circuit.

FURTHER ADVANTAGES.

The usual 6L7 expander circuit operates the tube with voltages of —13 and —15 on G_1 and G_3 respectively, with the result that the gain of the 6L7 under no-expansion conditions is very small. Now most 6L7's when operated in this manner produce about as much noise—hiss and microphonics—as signal, so that the operator is tempted to increase the input to try and over-ride this. Excessive distortion then becomes apparent, making the cure as bad as the complaint.

In our circuit this difficulty is overcome by working G_1 at —3 volts. This gives the tube much more gain, and the noise and microphonic voltages are successfully swamped by the signal, and are no longer troublesome.

Working the tube at higher gain, and therefore at a higher signal level has another important advantage. Mention has already been made of the filtering of the control voltage before it is applied to G_3. This function is performed by the R-C filter in the control voltage lead to G_3. This ensures that any audio frequencies which may come through from the diode circuit are prevented from reaching G_3. Unfortunately, the filtering effect is only perfect at the middle and high audio frequencies. This can be verified by turning the input control to zero. There should now be no output at any setting of the expansion control, but a certain amount of distorted low frequencies may be heard in the output. This undesirable feature is very much worse in the low-gain type of circuit, and the improvement has been achieved by working at higher gain, so that the signal is relatively stronger than this spurious low frequency response.

It is to reduce this response to a minimum that the cathode bypass condenser C_9 has been made comparatively small.

USING THE EXPANDER.

For best results, the expander must be used with a certain amount of care. First, and most important, it must be seen to that the setting of the input potentiometer R_1 is correct for the pickup that is to be used with the expander. The best way of adjusting R_1 is to turn the expansion control to zero, and listen carefully to a good record with various settings of R_1. Since the gain of the 6L7 is additional to that of the main amplifier, there will be plenty of gain available to allow a quite low setting of R_1. This will be necessary with most pickups, especially crystal ones, since these often have a peak output of several volts. Once the correct setting for R_1 has been found, this can be left untouched so that R_1 can be a pre-set screw-driver control, not brought out to the front panel.

Next, it is necessary to consider what type of record is most suited to expansion. Orchestral music is the most obvious example, and was used before by way of illustration. However, not all orchestral records are suitable for the expander, nor do they all require it. A piece of music that is uniformly soft, or equally loud all through is a case in point. Not many pieces are like this, though, and most orchestral records

(*Continued on Page 36*)

DESIGN SHEET—No. I

Turns Ratios of Matching Transformers.

Statements such as the following may be found in many text-books:—"A power amplifier must be matched to its load in order that optimum power transfer may be obtained." The same text-books, however, seldom make clear just what "matching" is, or why it is necessary.

There is a quite general law in electricity which states:—"For maximum power transfer from a generator to its load, the impedance of the load must equal the internal impedance of the generator." If this general law is applied to the special case of a valve (the generator) and its load, it becomes:— **"For maximum power transfer from an amplifier valve to its load, the impedance of the load must equal the plate resistance of the valve."**

Now the statement in black is quite true, but the fact remains that the load of a power amplifier is hardly ever matched to the plate resistance of the valve. This is because other considerations enter into the design besides that of maximum power output. The most important of these is the fact that minimum distortion occurs with a different value of load from the one which gives maximum output. It can be proved mathematically that the maximum **undistorted** power output of a triode is realised when the load is equal to **twice** the plate resistance of the valve. With pentodes and beam-tubes, the optimum load is always much less than the plate resistance of the valve.

With any valve, however, the optimum value of load impedance is usually quite different from the impedance of the device which is to be used as a load. For instance a single 2A3 requires approximately 2500 ohms load for maximum undistorted power output, yet it may have to feed a loudspeaker whose impedance is only 3 ohms. The process of matching the load of 3 ohms, therefore, consists in presenting it to the valve in such a way that to all intents and purposes it has an impedance of 2500 ohms.

This is where the "matching transformer" comes in. The current and voltage transforming properties of the transformer are separately easily understood. What enables the device to transform impedances is that both current and voltage transformations take place simultaneously. For example, if a transformer steps a voltage down in the ratio of 10:1, the current must at the same time be stepped up in the ratio of 1:10. This follows from the facts that power = current × voltage, and that the power in the primary must equal that in the secondary (assuming a loss-less transformer).

Thus, in the primary circuit we have high voltage and low current, while in the secondary we have low voltage and high current. Now a circuit handling a fixed amount of power under high voltage—low-current conditions must have a high impedance, and conversely, a circuit handling the same power under low voltage high current conditions must have a low impedance, so that the transformer can feed a low impedance load from a high impedance source without any power being wasted, and impedance transformation has been accomplished.

In using a transformer in this way, we must know what ratio of primary turns to secondary turns is necessary to effect the desired impedance transformation.

The answer is easily obtained by the following:— Suppose Zp and Zs are the impedances to be matched, and further that Ep and Es are the voltages developed across primary and secondary windings respectively. If W. is the power to be transferred, we have for the primary,

$$W = Ep^2/Zp \quad (1)$$

and for the secondary,

$$W = Es^2/Zs \quad (2)$$

$$\text{Thus, } Ep^2/Zp = Es^2/Zs$$

This last equation, rearranged, becomes:—

$$Zp/Zs = Ep^2/Es^2 \quad (3)$$

In other words the ratio of impedances to be matched must equal the **square** of the voltage ratio of the transformer.

The latter is the same thing as the turns ratio of the transformer, so that:—

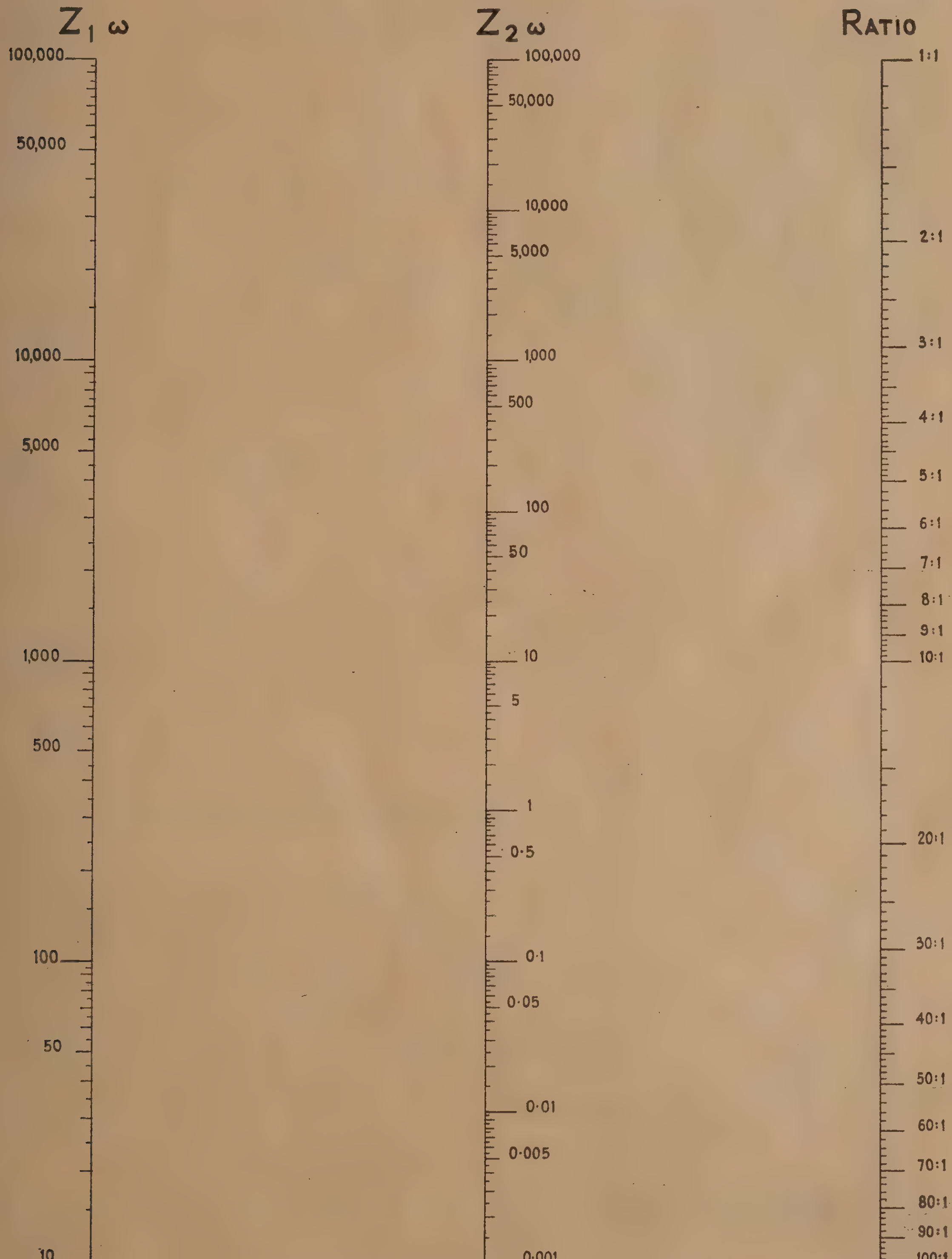
$$Zp/Zs = Tp^2/Ts^2 \text{ or } Tp/Ts = \sqrt{Zp/Zs} \quad (4)$$

Equation (4) enables us to find (a) the impedance that can be matched by a transformer with a given turns ratio or (b) the turns ratio required to match two given impedances. The sum to be worked out for any particular case is not a difficult one, but is inconvenient owing to the presence of the square root sign. We have therefore drawn the abacus on the opposite page, so that all such sums may be done simply by laying a ruler across the scales at the appropriate place.

The column labelled Z_1 represents one of the impedances, and that labelled Z_2 the other, while the third represents the required transformer ratio. Thus, if it is required to match 10,000 ohms to 100 ohms, the ruler is placed so that 10,000 ohms on the Z_1 scale and 100 ohms on the Z_2 scale are on the ruler edge. Where the latter cuts the ratio scale gives the answer, namely, 10:1. Conversely, if one has a transformer of ratio 4:1 and wants to know what impedance must be connected across the primary to match a secondary impedance of 500 ohms, the ruler is laid between 4:1 on the ratio scale, and 500 ohms on the Z_2 scale. The answer, 8000 ohms, is found where the ruler cuts the Z_1 scale. Examination of the scales will show that any impedance from 100,000 ohms to 10 ohms can be matched to any other impedance between 100,000 ohms and 0.001 ohm by means of the abacus, as long as the ratio of impedance is not greater than 10,000:1. Very few practical situations occur that are outside the range of the chart.

It should be noted that when using a matching transformer, the transformer itself does not impose any load upon the source of power. All it does is to enable the actual load to be coupled in the most efficient manner to the source or generator. In other words it makes the actual load appear to the generator as though the latter were coupled directly to a load of an impedance $(Tp/Ts)^2$ times the actual impedance of the load, where $(Tp/Ts)^2$ is the transformer turns ratio.

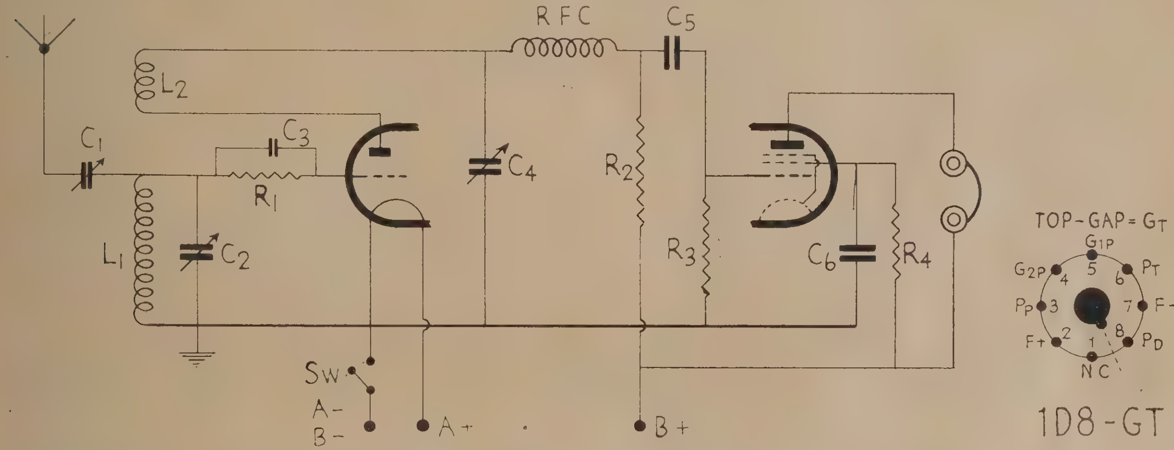
DESIGN SHEET No1 - Matching Transformer Ratios



MORE ABOUT "RADEL" ONE

When describing the Radel One in our last issue we stated that this month we would give some attention to the general operation of the receiver, but before proceeding further it is essential to give a word of warning to beginners and advanced constructors alike.

As a regenerative detector is in actual fact an oscillator when operating under certain conditions, it can be a serious source of interference to other neighbouring receivers. We therefore draw your attention to Regulation 72 contained in the "Radio Regulations, 1932," which states:



"In the case of receiving apparatus used on frequency bands reserved for broadcasting. (a) It shall be an offence against these regulations for any licensee or other person to use, or for any licensee to permit the use of, any receiving set in an oscillating condition to the detriment of reception by other licensees."

Summing up, then, it is definitely illegal to operate a regenerative detector, in an oscillating condition, unless preceded by a stage of radio frequency. It is much better to exercise care in manipulation than to invite the attention of your local radio inspector.

The design of the Radel One incorporates a typical triode regenerative detector and in this particular stage lies the secret of outstanding sensitivity of the set. The regeneration is introduced by coupling from the plate circuit back to the radio frequency input. At the plate output there is a combination of rectified audio voltage and an amplified R.F. signal voltage. The effect of this type of regeneration is to increase the radio frequency voltage applied to the detector and at the same time to produce a corresponding increase in selectivity. The increase in signal voltage will reach a limit which is governed by the amount of reaction required to cause the detector to go into oscillation, and when this occurs the received signal will produce a beat-note or whistle. When regeneration is carried as far as possible without oscillation occurring, the increase in amplitude is very great for weak signals and less, although still considerable, for strong signals. This factor explains the D.X. capabilities of the Radel One.

The amplification of a received signal when the detector is operating at the critical point, that is, when the detector has the maximum amount of regeneration without causing oscillation, is extremely large. Under favourable operating conditions the amplication of an incoming signal has been found to be as high as 15,000 times.

Unless great care is paid to the construction details of the Radel One many troubles may be introduced which may have a serious effect on the overall efficiency of the receiver. The most common and at the same time the most serious trouble is the "fringe" or "threshold" howl. This howl is usually apparent when the reaction is adjusted to the most critical point where oscillation is barely maintained. Obviously "fringe" howl, if particularly bad, will render D.X.-ing almost impossible. It frequently occurs when the detector output is fed into an inductive load such as transformer coupling to an audio stage. The Radel One uses resistance coupling, which reduces howl to a minmium, but it may also be caused

by the grid condenser—grid leak combination. There is no set value of these components to eliminate howl; consequently various combinations should be tried. Howl is usually caused by stray R.F. getting into the audio stage, and various precautions are: a very small fixed condenser placed each side of the R.F. choke in the detector output to earth, or connecting a .0003 m.f.d. by-pass condenser and choke in series with any long speaker or 'phones lead carrying plate current.

Another difficulty, particularly in the case of the beginner, is that of obtaining even reaction over the entire short-wave or broadcast bands. The specifications for coil dimensions are for the average number of turns required for the reaction coil. The turns may vary in number, due first to unavoidable differences in circuit capacity when constructing the set, and also to variations in H.T. voltage, so it is quite possible that the newly constructed set will not oscillate until an extra turn or so has been added to the reaction coil. The following procedure is an excellent one for finding the exact number of reaction coil turns with the minimum trouble. Tune to the lowest frequency of the band, adjust the reaction coil turns, so that the receiver will just oscillate when the reaction condenser is fully closed. The same procedure will apply for all bands.

Another trouble frequently found on short-wave bands is "dead spots," the effect being that the receiver will not oscillate at certain points on the dial. The trouble is usually due to absorption at that frequency by the aerial, which happens to resonate at that particular point.

Last, but by no means least, the aerial and earth system must be the best possible. Most installations will be governed by their particular localities, but where circumstances will allow, the aerial should be 100 feet from insulator to insulator and 30 feet or more high. The earth system should receive as much care as the aerial, and a good connection made to the water pipe by means of a good earth clip or a soldered joint. As an alternative, six feet of water pipe driven into moist ground may be used.

THE CANTERBURY PROJECT

In New Zealand at the present time preparations are going forward. and work will shortly commence on a large-scale experiment the results of which are of vital importance both to the applications of ultra-short-wave radio and to the science of meteorological forecasting.

In the early war years when for some time air-warning radar stations had been operating round the coast of Great Britain, it was forcibly brought home to the scientists responsible for the further development of radar, that radio propagation on wavelengths shorter than ten metres did not always take place in a manner that could have been predicted. It did not take a scientist to know that very short wavelength radiation behaved, after leaving the transmitting aerial, very similarly to light. Any amateur transmitter who had worked on the five-metre band or higher knew that such high frequencies confined communication to visual ranges, and that solid objects of any size caused a radio "shadow," within which reception was very poor or even non-existent.

It would have taken a very clever physicist, however, to predict that very marked deviations could occur from this normal behaviour on the part of ultra-high frequency energy, not to mention the somewhat startling fact that such deviations could be caused by variations in the weather. Such is now known to be the case, thanks to a multitude of observations made by radar stations all over the world, but first of all by operators of the R.A.F. air-warning radar system in England.

Before any operational radar stations had been erected the engineers and scientists responsible for designing the equipment had calculated with fair accuracy the ranges to be expected in observing aircraft and ships. If the transmitted power was great enough, the limiting factor was known to be the curvature of the earth, which could not be followed by the waves from the radar aerials. For high-flying aircraft, this limitation was not serious, because their range could be very great before they were below the horizon as seen from the radar station. But for low-flying aircraft and ships only very short ranges were expected; not so much because of limitations in the radar equipment, but from the geometry of the earth, and the known straight-line propagation of radio waves at the frequencies in use.

Great interest was therefore aroused by the fact that every now and then various radar stations recorded phenomenally long ranges on ships and low-flying aircraft. These ranges could not be accounted for by the theory that they were due to reflections from the ionosphere, for many of the stations affected worked on radio frequencies much too high ever to be reflected by it, so that an entirely new theory had to be formed. Steps were taken to collect all possible data on this "anomalous propagation" as it was called, and scientists went to work to discover the cause of it.

The first "find" was that on a large number of occasions when anomalous propagation had occurred, what is known to meteorologists as a "temperature inversion" had existed. Normally, as one ascends from sea level to a great height, there is a steady drop in temperature. Under certain weather conditions, however, the temperature may rise as one goes higher, and this is the temperature inversion referred to. It may take place from ground level to a certain height, after which the temperature falls in the normal way; or it may not commence until a few thousand feet above sea-level, the usual falling-off of temperature being apparent both above and below the inversion.

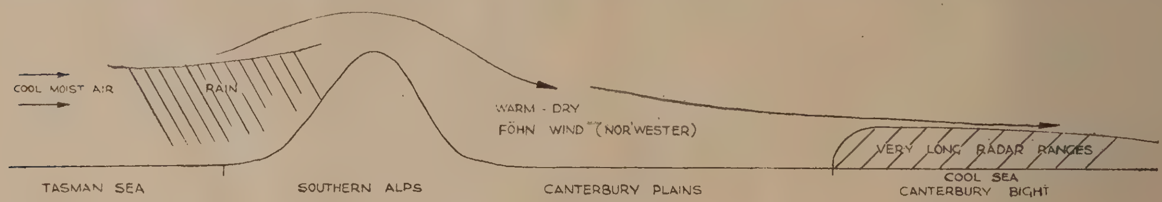
Here, then, was some evidence that the path taken by ultra short wave radiation was affected by weather conditions. But as more data were collected it became apparent that temperature inversions alone could not account for the observed effects.

About the same time, the problem was being tackled from the theoretical point of view. It was argued that for objects far below the horizon to be detected by radar, the radio waves must have been bent earthwards from their usual straight line path into space. If this bending is conceded, then the cause of it should be similar to the cause of the bending of light rays from a straight path, since radio waves and light are one and the same thing, except for wavelength. Now light rays are bent if they pass through a medium

whose density (and therefore refractive index) varies from place to place. Since its density decreases with height, the earth's atmosphere is such a medium, so that light rays are bent as they pass through it. In very hot climates, where sudden changes occur in the density of the air quite close to the ground, this bending is extreme, and is the cause of mirages. Thus, it seemed possible on theoretical grounds that ultra-short wave radiation could also be affected by changes in the density of the atmosphere, and that the radar detection of targets far beyond the horizon might turn out to be a kind of radio mirage.

from data supplied by the meteorological services. The importance of such predictions could hardly be over-estimated, and will be dealt with later.

In spite of the great amount of work done all over the world in collecting and correlating data on anomalous propagation, the end of the war did not see a satisfactory answer to the problems involved. Experimentally the subject is a difficult one, and indisputable conclusions are hard to reach. The reason for this lies partly in the difficulty of estimating propagation conditions, but mostly in the vagaries of the weather and



SIMPLIFIED DIAGRAM OF THE FORMATION OF A FÖHN WIND AND THE PRODUCTION OF VERY LONG RADAR RANGES

Theoretical work along these lines showed that variations in the density of the air were sufficiently great to cause the bending of radio waves on the frefuencies concerend, and that temperature variation was one of the responsible factors. This linked up well with the observations that temperature inversions had something to do with it, and brought to light a still more important factor—humidity variation.

Though variation in humidity of the atmosphere had not previously been in the picture, the theoretical work referred to showed that unusual distributions of humidity with height could have a much more powerful bending effect than temperature inversion, and explained many cases of anomalous propagation which had occurred when no temperature inversion had been apparent.

When this promising stage had been reached, special experiments were put under way with a view to proving or disproving the theories put forward. The problem of anomalous propagation was considered so important that large sums were spent and an enormous amount of effort was expended both in Great Britain and America in attempts to so weld theory and practice that predictions of anomalous propagation could be made

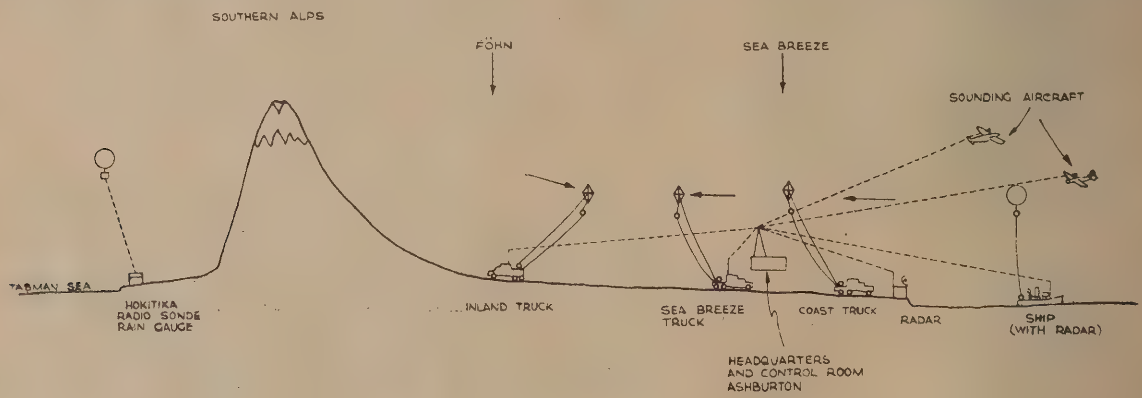
the taking of suitable humidity and temperature measurements. Here lies the importance of the Canterbury Project.

The Canterbury Project was born in 1944 when Dr. H. G. Booker, the foremost authority on anomalous propagation, visited New Zealand during the course of a world tour when he was collecting information to take back to his headquarters in England. He gave accounts of all the anomalous propagation work up to that time, and told New Zealand workers on the subject that the results already sent from here had been of considerable value to his team of scientists who were doing the bulk of the work we have referred to. He pointed out that all previous examples of planned experiments had failed up to a point, in that weather conditions at the localities chosen were so complex that the simple conditions which his theory would explain in detail were hardly ever found in practice. What was wanted, he said, was a place where throughout the year, warm dry winds of varying intensity blew over land and across the coast out to sea. These conditions favoured the occurrence of anomalous propagation, and were simple enough from the meteorological point of view to enable thorough practical tests to be made of his theories. In

other parts of the world, he stated, such winds existed, but at the time of speaking, the political situation did not allow their use by the Allies for large scale experiments! In any case, nowhere in the world was to be found a spot so suitable for the proposed investigation as the Canterbury Plains. Canterbury's nor-westers were the ideal warm dry wind for his purpose, since they blew with varying intensity all the year round, and were not complicated by extremely local weather disturbances such as had detracted from the results of other such experiments. On his departure Dr. Booker said that he intended to make the strongest recommendations, both in England and America, that a large-scale radio-meteorological experiment be carried out as soon as possible on the Canterbury Plains.

For some months now preparations have been under way, and before long the first measurements will be made. To give readers some idea of the amount of work involved, and the exact form of the experiment, here is a condensed account of the measurements that will be taken.

The measurements themselves will be largely of a meteorological character, and are far more numerous and complex than our brief description of anomalous propagation would lead one to expect. For the purpose in hand, single measurements of relative humidity and temperature are of little or no use. Measurements must be taken at a series of heights at various points on land and out to sea along a line at right-angles to the coast. The ideal arrangement would be to have all measuring equipment installed in aircraft, but



DIAGRAMMATIC SECTION THROUGH SOUNDING AREA

Accordingly, Dr. F. E. S. Alexander of the Radio Development Laboratory, and Dr. M. A. F. Barnett, Director of Meteorological Services, drew up a detailed plan for the proposed experiment. This plan was submitted to higher authorities at home and abroad by the Director of Scientific Developments, Dr. E. Marsden. Consideration and approval of such a large and costly undertaking by all the authorities involved naturally took some time, but authority for the project to go ahead was obtained just before the Japanese war ended. This delayed the start of work on the project, as it had now to be determined whether civil applications of radar and other ultra-high frequency devices warranted the expense of the programme. The project was further considered in this new light, and early this year final approval for the experiment was given.

this is impracticable, since conditions will not always allow aircraft to fly low enough. For instance, low-level measurements at night would not be possible. For this reason, use will be made of balloons, aircraft and a small ship.

The balloons will carry what is known as "wired sonde" equipment. This consists of the devices necessary to transform temperature and humidity variations into electrical signals. The latter are received on the ground via fine wires spliced into the fine nylon cable to which the baloon is tethered. As the balloon is wound up or down by means of a motor-driven winch, marks on the cable enable readings to be taken at specific heights. Since it will be necessary to take soundings at a variety of places, the balloons with their measuring and mechanical equipment will be mounted on trucks.

Over sea, measurements will be taken with wired sonde equipment flown from the deck of a

small ship. At heights outside the range of the balloon-carried equipment, aircraft will carry instruments aloft and will fly pre-determined courses and heights, taking measurements all the time.

In addition to the meteorological measurements, radar sets will be installed at strategic points on land. These sets will take signal strength readings on certain land-echoes and on special reflectors fitted to the ship and the aircraft. In this way, the presence of anomalous propagation will be indicated at the same time as temperature and humidity readings, and the dependence of one on the other will be under a constant check at the experimental headquarters.

Radio communication will play a large part in the control of the various teams who are performing the actual sounding. All sites will be in communication with the headquarters of the expedition, where a controlling officer will co-ordinate the entire effort. In turn, the controller will be in direct touch with the normal meteorological service. Since soundings will be taken only during nor'-westerly weather, the meteorological service will advise the controller when a nor'-wester is about to develop. The controller will warn all sounding sites to stand by for measuring, and will direct the mobile sounding teams to the most suitable sites, which will vary according to the development of the nor'-wester, and the strength of the sea-breeze, if any. The controller will judge from results (transmitted by the land stations by radio) when and where to send aircraft up, and what evolutions they should perform in order to obtain most information.

The work will go on for a period of a year from the commencement of the readings. During the whole period the process of correlation of radar data and meteorological data will go on, and the information gained will be put into suitable form for correlation with the existing theory.

The reader may well enquire "What useful results will spring from an added knowledge of anomalous propagation?" In the first place the military aspect is particularly important. During the war just ended, both sides made great use of ultra-high frequency communication and radar —particularly the latter. In addition, the known propagation of radar frequencies was used in planning air and sea-borne attacks. Avoidance of existing radar cover can often be used to cover up such attacks and re-introduce the element of surprise. One can readily imagine the havoc that could be caused by anomalous propagation if,

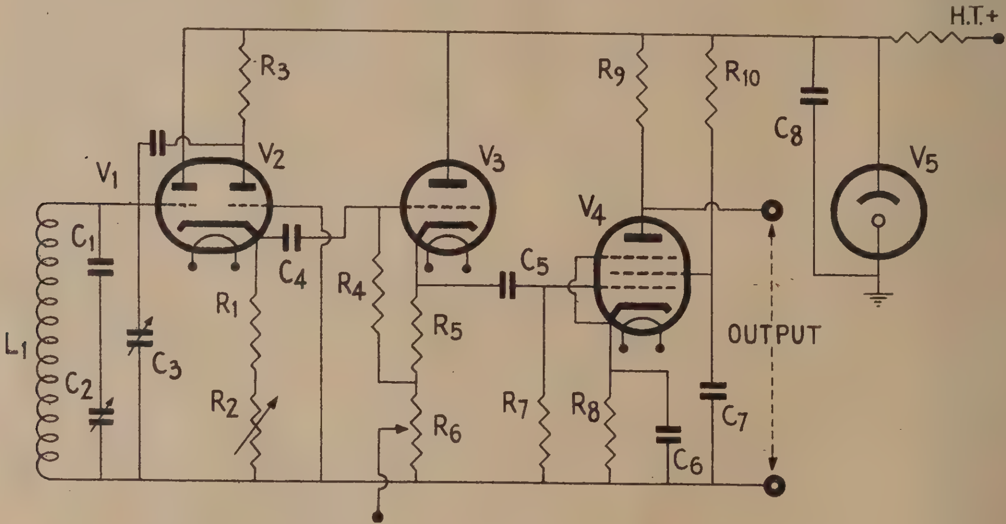
(continued on page 36)

FREQUENCY MEASUREMENT

Part III.

CONSTRUCTING THE STANDARD.

In Part II of this series, we described how an auxiliary oscillator, followed by a harmonic generator, may be used to produce a series of standard frequencies covering a very large band, and all of them harmonics of the auxiliary oscillator. This month we continue the discussion on the use of this simple secondary frequency standard, giving in addition practical details of its construction.



$V_1 + V_2 = 6N7$
$V_3 = 6C5$ or $\frac{1}{2}6SN7$
$V_4 = 6AC7/1852$
$V_5 =$ VR 150/30
$L_1 =$ Broadcast R.F. coil (see text)
$C_1 = 250$ $\mu\mu f$. silvered mica.
$C_2 = 300$ $\mu\mu f$. Max. Variable.
$C_3 = 10$ $\mu\mu f$. Max. Variable.
R_1, $R_5 = 500\,\omega$
$R_2 = 50$ k. Pot.
$R_3 = 50$ k.
R_4, $R_7 = 1$ Meg.
$R_6 = 50$ k. Pot.
$R_8 = 150$
$R_9 = 5$ k.
$R_{10} = 25$ k.
C_4, $C_5 = 100$ $\mu\mu f$. Mica.
C_6, $C_7 = 0.1$ μf.

As can be seen by the following description, a simple standard frequency source giving signals every 1000 kc/sec. will do most things that are required of such an instrument. Many will not wish to construct a more elaborate standard, so at this stage we will describe a suitable circuit, shown in the accompanying figure.

THE CIRCUIT.

V_1 and V_2, comprising a 6N7 double triode, are used as a negative-resistance two terminal oscillator. Output is taken from the cathode to a cathode-follower buffer stage. The latter excites a 6AC7/1852, used as a harmonic generator or distorting amplifier. V_5 is a VR150/30 voltage regulator tube.

There is nothing about the construction of this device that need cause any difficulty. Since it is a source of standard frequencies, stability is the chief consideration, and everything else should be subordinate to this point. Components should be of the best, and such items as variable condensers and the oscillator tube socket being of ceramic or polystyrene insulation. The use of high quality insulating materials is a major factor in building an oscillator that does not drift with temperature changes. The tuned circuit components L_1, C_1, C_2 and C_3 are mounted in a heavy iron or copper shield box, with the tube outside it. This is mainly for purposes of heat insulation, since such construction prevents the heat from the tubes from causing frequency drift. In the

prototype, the only wire emerging from the shield box was the one to the grid of V_1.

L_1 is a standard broadcast band R.F. coil. For use with the variable condensers specified, it should be one designed for use with a 450 $\mu\mu f$ gang condenser. Rather than possibly damaging the coil by cutting off the primary, which is not required, the latter was short-circuited and connected to the earthed end of the grid coil. No trouble was experienced after this, but before it was done, the oscillator tended to pull out at one spot on the dial. C_2 is used to set the oscillator very nearly to the proper frequency of 1000 kc/sec., after which the final zero-beat adjustment is made with C_3, which gives a variation of only a few kilocycles. The shaft of C_2 is brought out at the rear of the tuned-circuit compartment, and that for C_3 is brought out to the front panel.

The variable cathode resistor R_2 is used to set the oscillator so that it is just oscillating, or at least at the smallest amplitude which will allow the 6AC7/1852 to give sufficient amplitude on the high harmonics. Since R_2 alters the frequency of the oscillator it should not be brought to the front panel. A single adjustment will be all it will need, so that it is set once for all during the initial lining up. The small unmarked condenser between the plate of V_2 and grid of V_1 should not be greater than 10 $\mu\mu f$, as the feedback required is very small. If this condenser is too large the plate circuit of V_2 causes too much damping on the tuned circuit and oscillation may stop. The best condenser to use here is a 10$\mu\mu f$ silvered mica condenser. If desired, a midget air-dielectric trimmer may be used and adjusted to the smallest value that gives satisfactory operation.

The minimum cathode resistance for V_1 and V_2 is R_1, which has a value of 500 ohms. If R_2 is set to zero, oscillation will be most violent, and the oscillator itself will give high harmonic output. This is undesirable, however, since the purer the wave-form of an oscillator, the more stable it will be.

V_3, the cathode-follower, could possibly be omitted from the circuit, but it is not advisable to do so since it prevents all possibility of the connection of V_4 to a receiver, causing a shift in the oscillator frequency. In addition to this, it is particularly necessary in the further development of the circuit to include a 100 kc/sec. multivibrator. If it is not intended to construct the more elaborate standard, R_6 may be made fixed instead of variable.

IMPORTANT ANNOUNCEMENT.

Since the appearance of our first two issues we have heard many favourable comments on the setting out and clarity of our circuit diagrams. This is very gratifying, but it appears that our system of indicating joins and crossovers has caused confusion to some. The method used up to now has been to loop over where wires do not join, the tacit assumption being that where no loop exists, wires do join. This was once the standard way of indicating these things. In view of the difficulty experienced by some readers, we have decided on a change. This will be effective from the July issue, and consists in placing a dot where wires join while retaining the loop method of denoting a crossover.

It is advisable to use an external power supply for the standard. In the first place this is economical, since the instrument does not draw much current, and is not used a great deal, and secondly, it is desirable to keep as much heat as possible away from the instrument.

The regulated power supply is used to increase the stability. The regulating resistor will have a value dependent upon the voltage of the power supply used. It is useful therefore to make this resistor a 10 watt 10,000 ohm wire-wound type of the kind that has an adjustable slider. Whatever the power supply voltage used, up to 400v., this should allow the current through the VR tube to be adjusted to between five and 30 milliamps. Fifteen milliamps through the VR tube is a good compromise, but as long as the maximum of 30 is not exceeded, all will be well.

A small fixed condenser of say 10$\mu\mu f$ can be connected if desired between the 6AC7 plate and the output terminal, but this may be omitted, and coupling to the receiver made by wrapping a few turns of insulated lead round the aerial wire close to the set.

EXAMPLES OF USE.

We will assume that the oscillator of the secondary standard has been set accurately to its nominal frequency of 1 mc./sec. by zero-beating its fifth or tenth harmonic with WWV either on 5 mc./sec. or 10 mc./sec. The output terminal will

now give a series of signals on frequencies of 1, 2, 3, etc. mc./sec. The question is, how can these be identified one from the other?

This problem is not nearly as serious as might first appear, since comparatively rarely do we wish to measure an entirely unknown frequency. It becomes acute only in the ultra-high and super-high frequency region, where as yet the average radio man does not have to work.

The easiest method of identification is to use a calibrated receiver. In case this should look like a step backward, it must be pointed out that the calibration of the receiver used need only be approximate, and that an ordinary dual-wave receiver is quite suitable as long as its dial calibration is only roughly correct. The receiver used to set the secondry standard to beat with WWV may be used, since it is no longer required for that purpose. Even if the dial calibration is some way out, no confusion will arise unless the error is of the order of 500 kc./sec. In addition, as long as one of the WWV transmissions can be received, points on the dial may be identified by counting the signals received as the receiver is tuned over the band.

Where difficulty is likely to be met is if a calibrated receiver is not available. This case is not a very important one, since it does not often happen that the "unknown" frequency is completely unspecified, and since practically any receiver has a calibration of some sort. It will be deferred for this reason to a later section.

A typical case where a simple secondary frequency standard is of extreme usefulness is the calibration of an all-wave oscillator, such as a home-built signal generator. This case will therefore be described in detail.

A signal generator has been built with nominal frequency ranges of 500-1500 kc/sec., 1500-4500 kc/sec., 4500-13,500 kc/sec., and 9000-27,000 kc/sec. The dial is marked 0-100, and has a Vernier scale with which to read 0.1 division. Reasonable care has been taken in designing and winding the coils, so that although the tuning ranges will not be exactly as specified, it can be assumed that the errors will not be greater than, say, 1 mc/sec. at the low frequency end of the 4.5-13.5 mc/sec. band and 2 mc/sec. at the same end of the 9 mc/sec. band.

(1) 500-1500 kc/sec.

This may be calibrated without recourse to the secondary frequency standard at all. The method is to couple the signal generator very loosely to

(Continued on page 35.)

OUR GOSSIP COLUMN

Mr. B. G. Stephens, Managing Director of Turnbull and Jones, Ltd., is still on the sick list after being ill since last November. As he is not expected to return in the very near future, Mr. C. J. Lenihan, Auckland Branch Manager, is at present acting as the company's Managing Director.

We regret to record the death of Mr. Sid Evans, the popular Wellington traveller who passed away on April 11 after a protracted illness. As a tribute to his popularity many clients with whom Mr. Evans had been associated attended the funeral.

Mr. E. S. Tuck, who prior to the war was Manager of T. and J.'s radio department, has, by his own wish, vacated this position and is now travelling the Hawke's Bay and Taranaki territory. The position of Radio Department Manager is now held by Mr. D. B. Billing, who recently returned to the firm after service with the army.

Wing Commander C. A. Turner, Director of Signals, Air Department, has received advice that he has been admitted to the Institution of Electrical Engineers as an Associate Member.

The Editor of "Radio and Electronics" was shown over the Eveready Plant by Mr. D. Freeman (Production Manager) last week, and he was surprised not only at the size of the factory but at the many intricate pieces of machinery used. As "Radio and Electronics" is now compiling a series of articles on New Zealand's industry, the result of this visit will be an article on New Zealand-made batteries.

While there he had the proverbial cup of tea and chat with Sales Manager C. H. Hart and T. Jamieson. What with increased prices, new show-cards, and bringing the Dealer Mailing Lists up to date, "National Carbon" seems to be a very busy spot at the present time.

Mr. A. E. Poll, Managing Director of Philips (N.Z.) Ltd., is again back at the helm of the organisation after serving with the R.N.V.R. as a commissioned officer for a period of five years.

Specialising in the interesting and vital branch of anti-submarine detection, Mr. Poll's duties took him to almost every theatre of war.

Another well-known figure in the radio world is again back with Philips—Mr. R. Slade. To say "again back" is perhaps a slight verbal inexactitude, for in actual fact he did not leave the company. During the three and a half years he occupied the important position of Radio Controller, he was "on loan" by Philips to the Ministry of Supply. We know—and the radio industry as a whole will agree—Ralph did an outstanding job of work in the industry's wartime effort. His fairness and energy will not be forgotten for many moons.

Knowing that Mr. Swann of Swan Electric Co. had just taken up the reins again after eight months in U.K., U.S. and Canada we called on him to find out what he had seen while overseas.

Mr. Swann was very concerned about general conditions in England and told us that the news we receive here regarding the food conditions at Home are by no means exaggerated. In addition, England was striving to maintain her overseas trade even to the extent of severe curtailment of domestic consumption. This coming with the peace, when in actual fact England was expecting easier living conditions after six years of war, had a depressing effect on business. However, they realise that the only way to get back to normal is "really to get down to it" and keep industrial output up to the highest possible level.

From the technical aspect Mr. Swann was very impressed with Pye system of Television in which the audio frequencies are modulated on the flyback of the line time-base. This means that for both visual and audio transmissions only one transmitter, one frequency and one receiver channel are necessary. The reproduction was excellent and rather like home movies, the picture area being approximately 12 inches square.

The general opinion in England was that 405 line scan would not give the reproduction that was actually possible and we could expect anything up to 1000 lines in the future. Another impressive fact was that of production cost. In the motion picture film only one scene is taken at a time. It may contain only a few words and may be "shot" 20 times until perfect. In television the productions must of necessity be rehearsed as a complete show as staged in a theatre, with the obvious result that many shows must be in rehearsal at one time to provide a continuous supply of entertainment.

The most notable television development in America was the extreme sensitivity of the latest iconoscope. In demonstrations seen there Mr. Swann stated that televising was done in normal room lighting and needed little of the high intensity light associated with the motion picture industry.

F.M. was going ahead rapidly as one would naturally expect with a high quality interference-free system. Its major use in America, however, was in enabling a large number of transmitters to operate on the same frequency channel. For example, on broadcast frequencies a station in Chicago and one in New York on the same wave-length would obviously interfere, but with F.M. such is not the case, owing both to the high signal frequency and to the inherent interference reduction characteristic of the system.

5-inch Service Oscilliscope

(Continued from page 11.)

ning of the fly-back. The rapid fall in screen voltage happens at the end of the fly-back, or the commencement of the sweep. This constitutes a positive-going pulse coinciding exactly in time with the fly-back, and is the wave-form used to black-out the latter on the screen.

(To be concluded.)

FOR THE SERVICEMAN

In the past many servicemen have experienced difficulty in obtaining the I.F. frequencies of domestic receivers manufactured in New Zealand. We commence this information column with a list of receivers manufactured by Radio Corporation of N.Z., Ltd., and we will publish this type of data relevant to all New Zealand receivers as it becomes available from manufcaturers.

Model	Date	I.F. Freq.	Model	Date	I.F. Freq.
108	Aug. 1934	256	38	July 1937	456
109	Feb. 1935	465	43	July 1937	456
7D	Oct. 1935	465	67B	July 1937	456
7B	Oct. 1935	465	57V	Aug. 1937	456
5B	Oct. 1935	465	68V	Apr. 1938	456
15	Sept. 1936	456	77B	Aug. 1937	456
10	Oct. 1935	—	85	Mar. 1938	456
21	Mar. 1936	456	36	Apr. 1938	456
33	Aug. 1936	456	58V	Jan. 1938	456
5B6	Sept. 1936	175	84	Mar. 1938	456
7B6	July 1936	456	35	Jan. 1938	456
7BV	July 1936	456	60	Mar. 1939	464
18	Sept. 1936	456	54	June 1939	456
31	Dec. 1936	456	59	June 1939	455
39	Dec. 1936	456	88	July 1939	464
25	Jan. 1937	456	79	Aug. 1939	456
24	July 1937	456	49	June 1939	456

Model	Date	I.F. Freq.	Model	Date	I.F. Freq.
65	Jan. 1939	464	90	1941-42	455
64	Jan. 1940	455	70S	1941-42	455
72	Jan. 1940	455	56	1941-42	455
52	Apr. 1940	455	40S	1941-42	455
62	June 1940	455	50S	1941-42	455
51	June 1940	455	55	1941-42	455
66	Apr. 1941	455	75A	1941-42	455
75	Sept. 1940	455	75L	1941-42	455
75	July 1941	455	62S	1941-42	455
102	Aug. 1940	455	40	1941-42	455
80	Sept. 1940	464	201	1941-42	455
52S	Oct. 1940	455	56A	1941-42	455
63	Jan. 1941	455	66E	1941-42	455
22	Dec. 1940	455	86P	1941-42	455
12	Dec. 1940	455	70R	1941-42	455
100	Aug. 1940	175	70X	1941-42	455
101	Nov. 1940	175	50P	1941-42	455
69	Apr. 1941	455	66J	1941-42	455
86	Oct. 1941	455			

Turn to page 31 for an important announcement about our circuit diagrams

Measurement of Frequency

(*continued from page 32*)

the aerial lead of the receiver, leaving the aerial connected. The signal generator is tuned to zero beat with as many broadcast stations as possible, and the dial reading taken for each one. The broadcast stations used must, of course, be identified, so that their frequencies are known. A graph is now plotted of dial reading against frequency. If desired, the secondary standard may be used to give an accurate check of the 1000 kc/sec. point. To do this, the aerial is disconnected from the receiver, and signal generator and frequency standard are loosely coupled to the aerial terminal. The signal generator is tuned to where the calibration curve says 1000 kc/sec. should be, and if the calibration has been correctly performed, a beat note of no higher than a few hundred cycles will be heard. One high-quality commercial signal generator is stated to have a frequency accuracy of only 1 per cent., which is 10 kc/sec. at 1 mc/sec., but during initial calibration it should be possible to do much better than this. Whether or not the calibration will stay over a long period is another matter.

In the same way, 500 kc/sec. may be definitely located on the calibration curve by zero beating the 2nd harmonic of the signal generator against the 1 mc/sec. secondary standard. The receiver remains tuned to the latter, and the signal generator is tuned towards the low frequency end of the scale until the beat is obtained. The reading is then taken.

(To be continued.)

RADIO and ELECTRONICS

Back numbers of this journal may be obtained from S.O.S. Radio Service, 283 Queen Street, Auckland, and the Te Aro Book Depot, Ltd., 64 Courtenay Place, Wellington, C.3.

Volume Expander

(continued from page 17)

will repay the use of the expander. Similarly, not all records need the same amount of expansion. No hard and fast rules can be laid down, but each record should be judged on its merits. Play it through with varying degrees of expansion until the most lifelike effect is gained. If the expander is working properly and is judiciously adjusted, the best criterion is that the music should sound much more "real" than without expansion, but at the same time, no unnaturally loud crescendos should occur. When you have become used to one of your favourite records played with the expander, turn the expansion control to zero and listen to the record right through again. It is astonishing how "flat" and devoid of contrast the record will sound. On the other hand, when you hear a well-known crescendo build up to its climax in a way you have never heard outside a concert hall, you will become "expansion-minded" just as we did! But please! Remember to keep the input to the 6L7 as small as you can before you complain that the distortion is too great. And DON'T use the expander in the audio system of a broadcast receiver. Transmissions in this country are not quite well enough monitored yet to make it worth while!

Canterbury Project

(continued from page) 29

unknown to an attacking force, it enabled the enemy to plot their movements long before normal radar coverage would have done so!

In peace, too, a knowledge of all possible modes of propagation is essential if the fullest use is to be made of the ultra-high and super-high frequency regions of the radio spectrum. Mutual interference at these frequencies is very likely to be caused where directional aerials cannot be used. Undesirable fluctuations in signal strength can be caused at points near the maximum service range, to mention only two possible effects of anomalous propagation.

That such an important piece of research is to be carried out in New Zealand by New Zealand personnel is just another reminder, if such is needed, that this country is far from being off the map in the scientific and radio world, and is capable of carrying out work of world-wide significance.

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